1962

The growth of a rational, system approach to naval repair parts inventories: the introduction of military essentiality

Iverson, Robert G.; Fisher, Robert D.; Wenzel, Robert F.

George Washington University

http://hdl.handle.net/10945/12268

THE

GEORGE WASHINGTON UNIVERSITY

THE GROWTH OF A RATIONAL, SYSTEM APPROACH TO NAVAL REPAIR PARTS INVENTORIES: THE INTRODUCTION OF MILITARY ESSENTIALITY

Research Report prepared by

Commander Robert G. Iverson 1400/USN

Lieutenant Commander Robert D. Fisher SC USN

Lieutenant Commander Robert F. Wenzel 1310/USN

Lieutenant Orlando Stallings MSC USN

of the

Navy Graduate Financial Management Program

January 1962

Dr. A. Rex Johnson, Director

TABLE OF CONTENTS

Chapter | Page

INTRODUCTION

"Military logistics is a vast enterprise costing many billions of dollars annually. There are many ways of carrying out these activities - various combinations of spares, buffer stocks, depot repair, data processing, maintenance procedures, procurement practices, and so on."[1]

The purpose of this study is to trace the development of the Navy's repair part system and to explore a technique for determining the military essentiality of repair parts, and using these data as one of the parameters for the establishment of allowance lists and/or load lists. It is not the intention of this study to develop a super-sophisticated process, but rather to review present systems, study research presently in progress and submit a program with emphasis on practicality.

The age-old riddle of how much of what material will be required, where and when, must be answered with known precision. Intuitive-type decisions in the field of logistics cannot be afforded nor relied upon in present times. Timely logistic support is a necessity, but fleet readiness must live with restraints imposed by space, size and weight of the part, cruise length and budget. Accuracy and

---

[1]Hitch, C. J. and McKean, R. N., The Economics of Defense in the Nuclear Age, Harvard University Press, 1960.

flexibility are paramount and "readiness" is the sole payoff.

One of the major problems in the development of optimum military inventory control systems has been the need for a measure of the relative importance of supplying one item instead of another. It is generally recognized that some items are more important than others, but no way objectively of measuring and comparing the military essentiality of each item has explicitly been used in inventory control computations.[2]

Military essentiality is concerned with measuring the effects of parts failures on the capability of fighting units in executing their assigned missions.

This study is approached from the standpoint of a Navy-wide effort. In addition, compatibility of operating goals with practical fleet application are observed carefully in detail.

The diverse background of the members contributing to this research and study is considered an asset. The study will serve as a compilation of work in the subject area. It is hoped that it will contribute an unbiased evaluation of an operations research approach to allowance list problems, with emphasis on military essentiality inputs.

---

[2] Polaris: The Optimum COSAL Program. The George Washington University Logistics Research Project No. 347 008 (June 1961).

CHAPTER I

THE HISTORY OF NAVAL REPAIR PARTS SYSTEMS

The Background of Naval Logistics

Logistics, according to the Dictionary of United States Military Terms for Joint Usage, consist of

> those aspects of military operations which deal with: (1) design and development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposition of material; (2) movement, evacuation, and hospitalization of personnel; (3) acquisition or construction, maintenance, operation, and disposition of facilities; and (4) acquisition or furnishing of services. It comprises both planning, including determination of requirements, and implementation.

Navy logistics is primarily concerned with the support of weapons with which the blows of maritime strategy are struck. In this age of space exploration and air attacks, of missiles and nuclear weapons, there are some who consider the role of the Navy to be shrinking. As long as water-borne weapons platforms are required navies will exist. As long as the tactics of war and deterrence require the movement of vast quantities of materials and men, the seas will be used as a medium of travel. As long as navies exist there will be a need for improvement in their logistic support.

The sailing ships of Nelson's day were much more capable of casting off their dependence on land support than were World War II battleships. The increasing dependence of

ships on fossile fuels limited their ability to spend long periods away from land and increased the need for logistic planning and facilities. As ship designs improved and logistic facilities became waterborne, and therefore more mobile, the requirement for far-flung coaling stations decreased and navies once again became more dependent upon home-ports within the confines of their national boundaries. During World War II the United States Navy was able to keep the carrier task force of the Fifth Fleet at sea for seventy-nine days through transfer-at-sea replenishment. This tremendous accomplishment had not been anticipated nor even thought possible at the beginning of hostilities. It was a plan developed to fit the needs of the times. This and other World War II experiences formed a firm foundation for the current operational doctrines of the Sixth Fleet in the Mediterranean. The effort that is required to keep this fleet mobile has advanced navy logistics to a position never before obtained. The development of navy logistics planning has only begun, however. The advent of nuclear propulsion has opened the way for less dependence on vast quantities of fuel and the required shipping to furnish it, but has increased the requirement for further improvements in every other area of logistic support. This paper is directed toward one small but extremely important element of navy logistics planning--the supplying of materials needed to repair the equipments that are required to make today's ship an effective, mobile man-of-war.

The Growth of Naval Repair Parts Systems

The first war canoe probably left the banks of some navigable river without a spare oar, but one can be sure that each occupant had a spare weapon or a primitive plan for obtaining one. As ships became larger and the appreciation of their usefulness as battle platforms increased, consideration had to be given to keeping them afloat and keeping them mobile. The need for repair parts had arisen. The captain of the sailing ship was able to solve most of his repair parts problems by signing on carpenters, sailmakers and blacksmiths and providing them with a few tools and materials with which to ply their trade. The introduction of the iron clad, steam propelled ships in the late nineteenth century intensified the problems of naval logistics. As is often the case, technological development quickly outstripped logistic support capabilities. "Repair (hull) and machinery repairs beyond the power of the ship to perform for itself were now necessary."[1] The emphasis on such elements of logistics planning as the supply of coal and providing a network of repair facilities throughout the world is evident from the writings of the naval logistic planners and strategists of those times.

---

[1]Benjamin H. Williams, Emergency Management of the National Economy (Volume XIV; Distribution Logistics; Industrial College of the Armed Forces, Washington, D. C., 1955), p. 25.

Mahan, speaking to the War College in 1888, listed

> the secondary matters connected with the maintenance of warlike operations at sea" among the neglected subjects of naval science. "It would be amusing, were it not painful," he said, "to see our eagerness to have fast ships, and our indifference to supplying them with coal." In 1890, "looking forward" Mahan found our Atlantic shores and the Caribbean dotted with British bases, while we had not on the Gulf of Mexico "even the beginning of a navy yard which could serve as the base of our operations." In the Pacific it should be the "inviolable resolution of our national policy" that no European state should acquire a coaling station within three thousand miles of San Francisco. "For fuel is the life of modern naval war; it is the food of the ship; without it the modern monsters of the deep die of inanition. Around it, therefore, cluster some of the most important considerations of naval strategy.[2]

This emphasis on the broader aspects of naval logistics has continued to today. Repair parts were considered part of the fuel and repair problem. During this period they were not neglected but neither were they considered on a basis of total ship or total navy requirement. Those repair parts that were required for the ship's propulsion machinery were controlled by the technical bureau that was responsible for the machinery. Likewise, those repair parts that were required for the repair of ordnance equipments were under the inventory control of that technical bureau. Before and during World War II, each technical bureau built up its own system for supplying repair parts to ships. In

---

[2] Ibid.

general, these systems resembled each other in that the repair parts were procured with the equipments and provided to the ships in sets designed to provide maintenance support for one equipment. They were packaged in metal boxes which could, theoretically, be stored conveniently near the pertinent equipment. The experiences of World War II brought attention to the problems raised by this method of repair parts support. This attention led to an evaluation of the assignment of responsibility for repair parts support. The three basic considerations in repair parts support are, as with most areas of logistic support, what is needed, where it is needed, and how to get it there. The decisions as to what is needed and where, were, as indicated, the responsibility of the cognizant technical bureau. The decision as to how to get it there was a "supply" task but the responsibility for this function was divided between the Bureau of Supplies and Accounts and the technical bureaus. The weaknesses of the independent systems were manifold. Differences in replacement procedures, duplication of stocks, poor identification of items, lack of centralized inventory control and variations in procurement and stocking policies resulted in a waste of material, money and personnel.

> The disadvantages of such a situation as existed at the end of World War II should be manifest. The user had to employ different procedures in trying to obtain items under the different independent systems. Duplication of the more common technical items, roller bearings to mention only one, existed in large numbers

> in the several systems. This tied up capital needlessly in duplicated inventories. This situation led to shortages of items in one system with excesses of the same item or items in other systems, while few means existed for exchanging information on stock availability among the systems.[3]

The Integrated Navy Supply System

On February 14, 1947, the Secretary of the Navy, James Forrestal, approved the "Integrated" Navy Supply System. This system was conceived to eliminate many of the duplications of the World War II systems, to standardize procedures and to centralize control. All supply tasks were to be centralized under the Bureau of Supplies and Accounts. The primary responsibility for determination of requirements would remain with the cognizant technical bureau. These determinations would be based on technical evaluation, requests of the operating forces and inventory management considerations. The plan as finally approved was a compromise and, as experience has since shown, did not accomplish the improvements originally envisioned.

> The new Navy Supply System provided that control of the major end items of equipment -- these being the expensive, infrequently-issued items such as guns, air frames, or large engines -- would remain in the hands of the cognizant technical bureaus. It provided that control of equipments smaller than "major end items," repair parts and consumables, would be vested in an office, which would control one broad category of material, such as ships parts, ordnance repair parts, aviation parts or provisions, of the Navy's total inventory. This office would act as an inventory control point. The new system

[3]U.S., Navy Department, Bureau of Supplies and Accounts, Supply Support of the Navy, (NAVSANDA Publication 340; 15 September 1957), p. 17.

> effected a "marriage" of the technical and supply functions at the inventory control point. The inventory control point was directed to look to the parent technical bureau for guidance in technical matters pertaining to its particular material area, and to the Bureau of Supplies and Accounts for guidance relating to the performance of its supply functions.[4]

These "inventory control points" became known as Supply Demand Control Points (SDCP). For the purposes of this paper we are interested in the SDCPs established for the control of repair parts and the progress they made toward increasing the effectiveness of the Navy's logistic support capability for these items. In order to trace this progress briefly and still maintain continuity in our presentation we concentrate first on the shore establishment -- the bureaus of the Navy Department, SDCPs, supply depots and major repair facilities -- and then return to improvements that have been made in the repair parts inventory control procedures aboard ships.

The Integrated Navy Supply System retained the independent repair parts systems that had been established by the technical bureaus. An SDCP was established for each major category of repair parts -- ordnance, ships machinery, electronics, aviation. In addition an SDCP was established for control of submarine and aviation repair parts on the basis of their specialized nature and the critical effect

---

[4] U.S., Navy Department, Bureau of Supplies and Accounts, Supply Support of the Navy (NAVSANDA Publication 340; 15 September 1957), p. 18.

these parts had on the mission of these craft.[5] The first big problem faced by the new supply system was to eliminate duplication. Thousands of items had been procured for Navy inventories during World War II. These items were identified by manufacturer's part number and had to be identified and catalogued in such a manner as to be easily ordered by the user and more readily controllable by the inventory control point. Items were identified, assigned a Standard Navy Stock Number (SNSN) and grouped by like category and by "cognizant symbol," which identified the SDCP or inventory control point that was assigned responsibility for inventory control. This process eliminated much of the duplication within each repair parts system. There were still parts needed for equipments supported by one system -- ordnance for example -- which were also needed for support of another group of equipments controlled by another SDCP. This was particularly true in the case of "electronics," an equipment category that was rapidly being applied to all areas of ship control. Inventory control assignments were, therefore, revised on a "Program Support" and "Supply Support" concept. Under Program Support an SDCP was assigned the responsibility for assuring that all items of repair parts required for the maintenance of a particular equipment or group of equipments were available in the supply system.

---

[5] This was, in effect, formal recognition of the greater military worth of one type of repair part as compared to another.

This SDCP did not necessarily have the inventory control responsibility for <u>all</u> of these items. Items were categorized into "parts peculiar" and "parts common." The Program Support SDCP was responsible for accepting the inventory control responsibility for a "part peculiar," a part used only in an equipment for which it had support responsibility. The Program Support SDCP would request the SDCP that had "supply support" responsibility to maintain an adequate supply of the "parts common" -- parts that were needed to repair many different types of equipments. Although there were some "holidays" in repair parts support as the result of this new concept, much duplication of inventories in the ashore supply depots was eliminated. Cognizant symbols of many repair parts were changed to indicate the change in inventory control assignments and the repair parts now needed to support any one piece of equipment might well be under the inventory control of three or four SDCPs.

> It has been estimated reputably that there were two and one-half million items in the Navy Supply System in 1947. Today (30 June 1957) there are only a little under 1,200,000 items......this reduction in the number of items in the System was achieved in a period when literally thousands of new items continued to enter the System each month as a result of the adoption of new and more complex equipments.[6]

The Program Support and Supply Support concept contributed substantially to this reduction in inventory.

---

[6]U.S., Navy Department, Bureau of Supplies and Accounts, <u>Supply Support of the Navy</u> (NAVSANDA Publication 340; 15 September 1957), p. 27.

> Another example of the use of these two assignments is that of the recent assignment to the Electronics Supply Office of "Supply Support" of all "common" electronics parts. This means that any SDCP receiving "Program Support" for an equipment will now know that for all electronics parts listed as being "common" that "Supply Support" has been and will be furnished through the system controlled by the Electronics Supply Office. This assignment to ESO has resulted in a transfer of approximately 40,000 items from five inventory managers to the control of the Electronics Supply Office. After transfer, it was found that a net saving of 34,000 items could be accomplished since requirements of most of these items could be met by items already in the System or by "preferred substitutes."[7]

The SDCPs controlled the distribution of repair parts. They did not actually store or physically distribute the material. Inventory status information was centralized at the SDCP on the basis of Consolidated Stock Status Reports submitted by the supply depots and major repair activities. The number of items under the control of an SDCP was of such a magnitude that they had to be separated into groups of items having similar characteristics such as item demand for efficiency in management. A code was assigned to the item stock number to indicate whether it was "fast-moving" or "slow-moving," for example. Other codes indicated whether the item was universally stocked and if special controls had been placed on its issue. In addition, inventories were segregated into broad groupings based on the purpose for which held. These over-all purposes were current operating stock, mobilization reserve, and excess. The assignment of

---

[7] _Ibid_., p. 28.

these codes was, as a rule, based on the "dollar activity" of the transactions involving these items. Each code provided a basis for application of different replenishment periods and procurement techniques as well as determination of the optimum procurement quantities. (This practice of categorizing items on the basis of demand was another indication of the formal recognition of variations in the military worth of an item.)

Advances in Shipboard Repair Parts Inventory Control

When the Integrated Supply System went into effect, shipboard repair parts were being stocked in accordance with the requirements of the technical bureaus. Each bureau used a different medium for making its requirements known to the ship. These documents were known as "Allowance Lists." They contained the technical bureaus' best estimate of the parts required to support a given equipment. The format differed for each technical bureau. Generally, however, the basic information provided was similar. Each major piece of equipment on the ship was identified by model number and manufacturer. Its component parts were listed and cross-referenced to detailed assembly plans which described the equipment's physical features. The assembly plans were provided separately in operating instruction books and/or in complete sets for major ship systems. The allowance list set forth the quantities of each repair

part required to perform repairs that the technical bureaus considered within the ship's capabilities. Certain repair parts were considered so vital to the operation of the ship that they were to be carried even if their installation could not be accomplished without the assistance of a repair ship or a shipyard. "Usually an engineering safety factor of at least one hundred per cent was employed to lessen the possibility of running out of a technical item."[8] The repair parts were provided at the same time that the basic equipment was installed. As greater quantities of more complex equipment was placed aboard ships and aircraft, the space requirements for the larger or more numerous repair part boxes exceeded the space available, especially in destroyers, submarines, and large aircraft. (Most small aircraft carried very few replacement parts.) In addition, many equipments, particularly electronic, utilized identical parts. This resulted in much duplication of inventories aboard these craft. As previously indicated, the use of a manufacturer's part number for identification, often restricted the amount of information available on which to determine interchangeability. Even after the improved identification system was introduced -- the assignment of Standard Navy Stock Numbers to all repair part items -- there was little reduction in the duplicated items aboard ship.

---

[8] Ibid., p. 29.

There were several reasons for this. First, repair part boxes were packed for a specific equipment and not for a specific ship or aircraft. If the ship had a multiple installation of identical equipments it would receive one repair parts set for each unit. Secondly, each ship maintained several repair parts systems which coincided with the organization in the shore establishment. Repair parts were usually under the custody of the division or department responsible for the maintenance of the associated equipment.[9] Often, even if interchangeability could be established, the needs of the department dictated the duplication.

Several approaches were initiated to eliminate or reduce these areas of duplication. When the ship's equipment list contained multiple units of the same equipment the allowance of repair parts was reduced by providing a complete set of repair parts of the initial unit only and providing other complete sets for only a portion of the additional units. This "portion" was determined on the basis of the importance of the unit to the operability of the ship and the probability of more than one unit being disabled at

---

[9] At this point it is considered important to remind the reader that these systems were designed to coincide with shipboard departmental responsibility assignments and adhered to the basic military policy of assuring that each commander has control of his logistic support. This policy is as old and deep founded as the military organizational structure itself. It is often considered to exist only on the command level, but even the individual foot soldier's equipment pack has been influenced by it.

the same time. Military worth was once again an element in the requirements decision.

Perhaps the most significant development from the point of view of its far-reaching effect on current repair parts systems was the discarding of the repair part boxes in favor of centralized bin or drawer storage. The requirements determination base shifted from the individual unit to a grouping of like equipments. The foremost proponent of this approach was the Electronics Supply System. The duplicity of items common to the needs of all electronic systems, space limitations, and cost all contributed to the birth of this development.

Duplication still existed in the shipboard repair parts organization. In recognition of this the Coordinated Shipboard Allowance List (COSAL) Program was established in December 1956.[10] The major objectives of this program were:

1. Development of Standard Allowance List Format. The various allowance list sections were to be published in standard format in order to increase their universal understandability and to allow their preparation and maintenance by mechanized processes.

2. Centralized Storage of Shipboard Allowance List Materials.

---

[10]U.S., Navy Department, Office of Chief of Naval Operations, OPNAV INSTRUCTION 4441.4 of 20 December 1956.

All repair parts carried on each ship were to be "bin-loaded."

3. Consolidation of Requirements.

The most important objective of the COSAL program was the consolidation of requirements of the various repair parts systems on board ship. This consolidation was now possible due to the inception of the Program Support and Supply Support concept. Although it required the transfer of the allowance list publication responsibility from the technical bureau to the SDCPs, the responsibility for the determination of requirements was to remain with the technical bureau.

Other Areas of Improvement

> Change is inherent in the order of things. Insofar as the forces which it is designed to support change, logistics must change. As far as possible, logistics must anticipate the changes necessary to achieve the support requirement. In this sense, logistics is always a "problem" - how to change to meet actual or anticipated requirements of the supported forces. During the evolution of the Navy the logistic support system has been adopted to meet the developments of the day. The changes from the ram to the gun, from the smooth-bore cannon to the rifled cannon, from sail to steam, from coal to oil, have been described in turn as revolutions. By comparison with the changes taking place today, and the rate of change, these earlier developments appear in retrospect to have a somewhat lesser stature.
>
> At no time in the Navy's history has the challenge to adapt to change been so great as it is today. A former Secretary of the Navy has stated the nature of the current problem. "The Navy is presently going through the most tremendous change it has ever undergone. It is passing from steam to nuclear power,

> from gunpowder to nuclear weapons, from guns to guided missiles, and in the air from propeller-type planes to supersonic planes, all at the same time." Undoubtedly, the emphasis in this statement should be placed on the last phrase, ". . . all at the same time." Here lies the substance of today's demand for adaptability in the supply support organization.
>
> The ten year period following the inception of the "Integrated" Supply System has witnessed technological advances which have revolutionized the basic concepts of warfare. This same technological progress has introduced elements of strategy, tactics, and logistics, which were undreamed of earlier. Responsiveness of the supply support system becomes an increasingly complex task in view of developments such as the wide dispersal of the Fleet, the current emphasis of mobility and instantaneous retaliatory capability, the complexity and high cost of equipments and materials, and the increasing dependence on engineered systems. The ever-accelerating rate at which new equipments are being installed has vastly increased the range of backup parts required to support the Fleet and the aircraft squadrons and further necessitates a tailored, tightly-controlled, flexible, distributive system.[11]

The review of the growth of the Navy's repair parts system up through the introduction of the COSAL program emphasized the organizational changes which had been made. During this same period it was determined that the logistic support to be furnished by the Navy Supply System also necessitated adjustments and improvements in requirement forecasting, allowance determination, stock distribution, management policy and control techniques other than those already mentioned. Common to all these areas was the need for a review of data collection, transmission and utilization.

---

[11] U.S., Navy Department, Bureau of Supplies and Accounts, Supply Support of the Navy, (NAVSANDA Publication 340; 15 September 1957).

The following summarization of the efforts that have been directed to some of these problems is pertinent to purpose of this dissertation:[12]

A. Improvement in Forecasting of Material Requirements.

Improvement in the capability of the Navy Supply System accurately to forecast requirements for material has been found to be the most important element necessary for the continued success of the System in meeting its modern mission. In the area, the Navy is working on the development of a single usage-data collection system, to satisfy all supply system needs; a system which will place a minimum burden on the fleet. Steps are being taken toward the completion of realistic and comprehensive population-data programs at the SDCPs. The Navy is looking to research, (advanced mathematics and improvement in statistical techniques) for over-all improvement in the entire area of consumption forecasting.

B. Better Balance in Items and Quantities Carried Aboard Ship

The current emphasis on fleet mobility and retaliatory capability has focused attention on the control of afloat endurance, and the fact that the latter is dependent on the coordinated development of more scientifically

[12] U.S., Navy Department, Bureau of Supplies and Accounts, Supply Support of the Navy, (NAVSANDA Publication 340; 15 September 1957), pp. 40-43.

prepared allowance lists. The Navy is working on coordinating the development of these allowance lists between the technical bureaus and the "supply" bureau. It has been recognized that allowance list preparation is no less a problem of stock distribution in response to a forecast of consumption than is the problem of determining range and depth of stocks to be carried ashore. Furthermore, since allowance list material must be considered as a pool of consumption stocks, the necessity of achieving an interdependent and compatible relationship between these stocks and the backup replenishment stocks is evident. The Navy is working on several programs for unified integrated allowance lists for ships.

C. Tailored Distribution Concepts

The basic "echeloned" nature of Navy distribution has been discussed. Greater recognition must be given to the fact that consumer stock levels (including allowance list material) must be considered as a phase of the distribution process, and consequently inter-related to the stock levels at the replenishment activities. Too frequently, the Navy is uneconomically pyramiding the stocking of low-demand insurance technical items at all distribution levels. The ultimate decision on stock positioning in an echeloned distribution system must be based on full consideration of such factors as demand characteristics, military essentiality,

cost data, and the availability and utilization of rapid transportation and communication media.

The systematic development of automatic data communication networks and the availability of premium transportation make possible the rapid passing of action on any supply request. This ability can go far in substituting for wide distribution, without loss in effectiveness or economy. During the summer of 1956, the Aviation Supply Office was linked by a transceiver network to its important primary stock points. On 1 October 1956, project FAST (Fleet Air Support Test) went into effect in the Atlantic Fleet to test the feasibility of increased use of air transportation to supply these sporadic-demand technical items to an active fleet. The success of this program has increased logistic effectiveness.

Vulnerability is one of the most serious problems confronting the Navy Supply System in this atomic age. A great portion of the Navy's stocks are positioned in prime target areas. Those are generally in coastal areas, which are among the leading industrial, population, harbor and rail centers of the United States. This problem of vulnerability of stocks is receiving the increased attention it merits.

D. Simpler and Faster Service to the Customer

Today a customer still must type out a requisition, and wait an appreciable time while that requisition is

processed before he gets his material. All manner of means is being sought and tested for simplifying the "demand" phase and the internal handling of paperwork at all distribution outlets. For certain commodities the fleet is requisitioning entirely by merely marking quantities on prepunched accounting machine cards.

E. Improved Evaluation of Cost and Other Factors

In the past "military necessity" was used as an overriding consideration to all cost factors in certain logistic decisions. Adequate attempts had not been made to isolate and evaluate "military value." Differentiation and measurement of the various elements of cost, such as "cost to purchase," "cost to distribute," "holding cost" and "cost of movement," have not been adequate. In the interest of improved decision-making, the Navy is taking advantage of modern scientific techniques to weigh properly these various factors.

F. Measurement of System Effectiveness and Control

The Navy Supply System can be described as one wherein control is centralized in the Bureau of Supplies and Accounts and the inventory managers, but where operations are decentralized to units of the distributive system. The ability to control decentralized operations depends upon the availability of management statistics which measure the responsiveness or effectiveness of the System to operational

requirements, and the efficiency of the internal operation. The development of controls to accomplish this is a task of great complexity. The Navy is working to develop objective-standards to a much greater degree in this area. The clarification of the cost factors mentioned in the paragraph above is part of the solution, including a measurement of the effectiveness of consumer stock levels. The Navy is striving to complete its statistical coverage of system operations.

G. Better Procedures for Inventory Control

The Navy is seeking the best use of modern work-and-timesavers, such as automatic data processing and fast data transmission. As has been stated previously, the problems of data collection, transmission, and processing, are common to all of the problem areas. In none of these is a better solution more urgent than in inventory control. In a system of one million plus items, involving tens of millions of transactions yearly, the difficulty of reporting a stock position at any given time should be obvious. The increasing use of improved automatic data processing equipment offers the only hope of obtaining inventory positions more quickly and accurately. The Navy is presently operating the latest of these equipments in both its aviation and ships parts inventory segments, and planning to do the same in other segments as quickly as possible.

CHAPTER II

THE COORDINATED SHIPBOARD ALLOWANCE LIST PROGRAM: AN EVALUATION

Progress is painful. Improvement requires change. One change leads to another. Continuous change can lead to confusion, disorganization, loss of direction and, inevitably, disagreement. During the years immediately following the establishment of the COSAL program a growing need for a complete evaluation of the results of all the changes that had accompanied this program was developing. The Supply Availability Program, initiated to assist ships "in the purification and adjustment of on-board stocks and records to bring them into conformance with prescribed allowances or other stockage objective criteria,"[1] brought to light many deficiencies in the entire repair parts system. In addition, during this same period a new dimension was being added to naval warfare and to the naval mission. The polaris missile firing, nuclear powered submarine, U.S.S. GEORGE WASHINGTON, was being rapidly readied for sea. To exploit this new dimension to the fullest, the latest techniques and developments in logistic support were

---

[1]U.S., Navy Department, Bureau of Supplies and Accounts, BUSANDA INSTRUCTION 4441.3A, 4 January 1960.

utilized. Without adequate repair part support the combat value of this modern weapon would be jeopardized. Complex electronic detection, guidance, fire control and communication systems were being installed on many ships. More than ever the system for repair part support needed to be capable of supporting the means for "push-button" retaliation. For this condition to be met, the system had to be effective, efficient and proven by peacetime utilization, and had to exist NOW.

The United States Navy, being the dynamic organization that it is, was not content with the system in being. By early 1961 the Navy had substantially completed the conversion to the COSAL. Deficiencies still existed. In February 1961, the Policy Advisory Council of the Bureau of Supplies and Accounts met to consider this allowance list program, its objectives, and the progress that had been made toward the accomplishment of these objectives. Membership of this group consisted of those senior officers whose assignments placed them in a position of responsibility for that portion of the Navy's logistic support represented by allowance documents. Since the principal items covered by allowance lists are repair parts, much of the material presented at this meeting is pertinent to the development of the subject matter of this paper.[2]

---

[2]Much of the material in this chapter was taken from the formal presentation prepared and presented by the

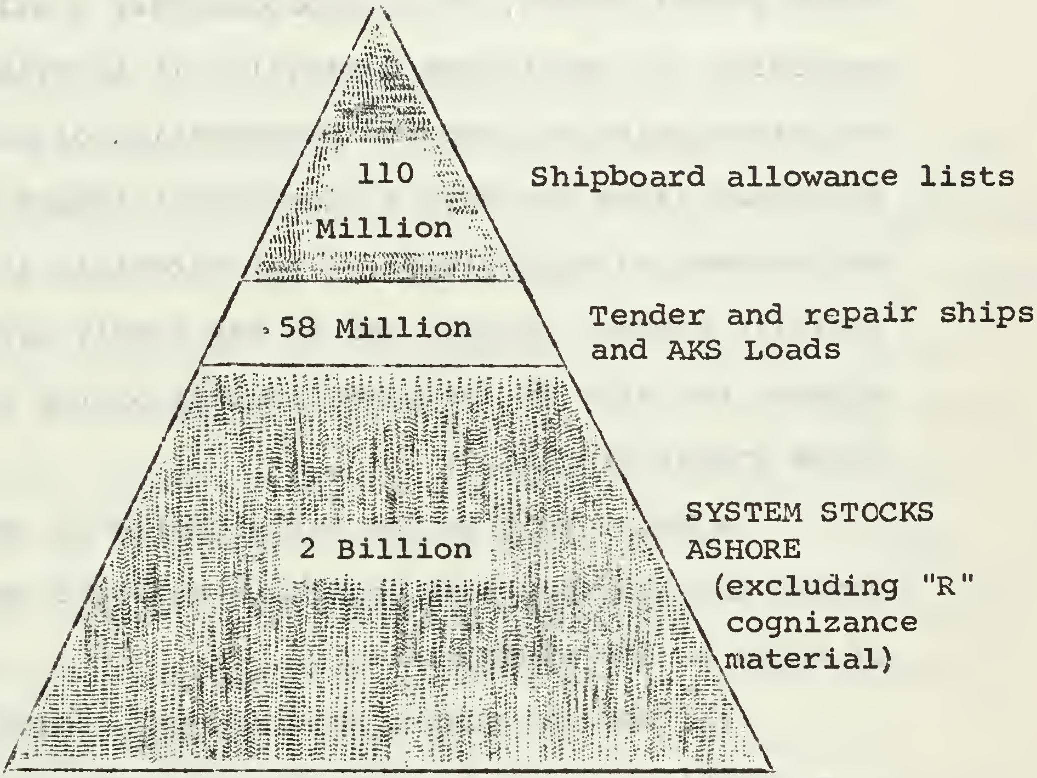
Scope of the Fleet Allowance Program

Shipboard allowance lists are important as an effective tool for shipboard supply management. Of key importance is their effect on the endurance capability of our operating forces. Allowance lists serve as guides for accomplishment of the initial outfitting of newly commissioned ships, as technical documents as well as supply documents for inventory management afloat, and as our only available measure of a ship's supply readiness. Moreover, the criteria and policies which govern the construction of shipboard allowance lists have an extensive influence on many other actions of the supply system at the shipboard, fleet commander, stock point, inventory manager and technical bureau level. Allowance decisions have a direct or indirect impact on many functions such as provisioning, procurement, budgeting, transportation, fleet funding, investment levels, shipboard storage and record keeping, and packaging and preservation.

---

officers and civilians assigned to the FLEET OPERATIONS DIVISION of the Bureau of Supplies and Accounts. Permission was given to use this material for the purposes set forth herein. The data have been reduced, reorganized and is presented in a manner considered more suitable for our purposes. A consciencious attempt was made to avoid distortion and "quoting out of context." Where exact duplication exists, it is considered to be in the interests of accuracy and emphasis. Where reference to other sources is pertinent, appropriate footnotes appear. Reference to the formal presentation, which has not been published, would be repetitive and redundant, as would an attempt on our part to duplicate this authoritive and objective analysis.

What is the total investment represented by allowance type material afloat and ashore? Below is a graphic presentation revealing the distribution of the repair parts inventory by dollar value.



NAVY REPAIR PART INVENTORY DISTRIBUTION

Considering only secondary items under BUSANDA management cognizance, excluding R cog items, shipboard allowance lists represent approximately 110 million dollars of

material. This segment of material represents the fleet commander's first echelon of support. Materials in the second echelon of support, which include our tender, repair ship and AKS (supply ship) loads, is valued at approximately 58 million dollars. Our systems stocks ashore, including material for support of the fleet and for support of the shore establishment, total approximately 2 billion dollars excluding "R" cognizance material. It is evident that the decisions which go into the construction of our shipboard allowance lists can have a significant impact not only on the volume and composition of the materials in our mobile logistic support forces, and in our supply system stocks ashore, but also in the effectiveness of the support that these stocks provide.

A brief look at the dollar value of investment represented in allowance list materials on board specific types of ships is now appropriate.

The USS SEA FOX, a conventional submarine, carries over 6000 items valued at $93,000. A MIDWAY class carrier carries 28,800 allowance list items (exclusive of R cog) valued at $917,000. A DDR, the USS FECHTELER (DDR-870), carries over 15,000 items valued at almost a quarter million dollars. Our first fleet ballistic missile submarine, the USS GEORGE WASHINGTON, dramatically exemplifies the changing trend in scope of support to be provided afloat. The

SSBN 598 carries about 25,000 items valued at one and a half million dollars!

Charts one through four on pages 81 through 84 depict the volume and dollar value of spare parts carried aboard various types of submarines and ships. After viewing these figures one can appreciate the scope of the allowance list problem.

Objectives Set Forth by the Chief of Naval Operations

The basic purpose of the COSAL program as set forth by the Chief of Naval Operations is to "enhance the endurance of the Operating Forces."[3] It is CNO's desire that our ships will have a maximum built-in endurance of allowance list items to enable ships to perform their missions independent of outside logistic support. The degree of support to be provided for the various categories of material is based upon the concept of obtaining a uniform duration of support for the numerous equipments involved. To achieve this objective, our allowance lists must be (1) responsive to changes in shipboard equipments and must accurately reflect changes in the range and depth of support material. The need for closer Navy-wide coordination in the program requires that (2) allowance lists be standardized, both to format and content. As a prerequisite to standardization of content, a (3) uniform system of usage data collection

---

[3]U.S., Navy Department, Office of Chief of Naval Operations, <u>OPNAV INSTRUCTION 4441.4</u> of 20 December 1956.

needs to be developed and implemented to assist in determining the range and depth of repair parts to be included on shipboard allowance lists. As a further (or alternate) means of refining the contents of shipboard allowance lists, (4) a means of determining the relative military worth or military essentiality of equipments and repair parts needed to be developed and implemented. Finally, because of space constraints aboard many types of ships, (5) the Navy's program for conversion to "bin-drawer" stowage was to be extended to all categories of repair parts carried on ships of the active fleet.

To assist in the accomplishment of these objectives, the following guidance was provided by the Chief of Naval Operations:

(1) Allowance lists will be based on wartime need.

(2) The range (variety) of items will take precedence over depth (quantity of an individual item).

(3) Shipboard allowances will take into consideration specific data such as weight, cube and endurance loading characteristics (shelf life) of individual items.

(4) The items included in allowances will, except for special cases authorized by CNO, be within the capability of the ship's force to install.

(5) In recognition of the requirement for a period during which actual shipboard stocks can be brought into agreement with newly prescribed allowances, active fleet ships will be granted supply availability periods normally as an extension of the ship's regular overhaul period.

> Designated shore establishment activities will assist the ship's force to accomplish complete "purification" of shipboard repair parts inventories, including offloading of excesses, requisitioning of deficiencies, updating of inventory control records and actual endurance loading of items susceptible to loading under this concept.

It is essential to recognize that implementation of the program is to be achieved through coordinated action and that the development of allowance lists is to be in conformance with the following requirements:

(1) Allowance lists are to serve as technical documents to describe and establish mandatory quantities of on board equipments, equipage and directly supporting materials (including repair parts).

(2) Allowance lists are to serve as supply documents to be the basis for shipboard inventory management.

(3) Allowance list materials are to represent the first echelon of supply to fleet forces and, to a large extent, will determine the duration of independent operations by a ship.

Conclusions of Fleet Operations Division of the Bureau of Supplies and Accounts

Probably the most important objective of the program is to assure that allowance lists are effective. Although the COSALs have answered the need for a standard, uniform document and represent a significant advantage over their predecessors, they do not automatically guarantee a better quality allowance list. To be effective allowance lists must be responsive to ships' equipment changes and reflect fleet

experience in the use of repair parts and related materials. It was intended that particular emphasis be exerted toward achieving a goal of completely responsive, effective allowance lists. Toward this end the basic instruction provides the following criteria as guidance in determining the range and depth of a ship's allowance:

> Material will be limited to items necessary to maintain essential equipment operable and be within the capability of the ship's force to install.
>
> Weight and cube of items must be considered in light of ship's weight and space limitations.
>
> Practicability of meeting every contingent requirement dictates that "need" rather than "desire" will govern.
>
> Range of allowed items is more important than depth of allowances.
>
> Allowances shall support wartime needs.

When accomplishments under the objective of effectiveness are gauged against the guidelines and within the specific criteria provided by CNO, the results are less than acceptable. Weaknesses may be summarized thus:

a. Responsiveness to ship's equipment changes and fleet usage experience is in some instances totally lacking; in others the reaction is slow and untimely.
b. Fleet equipment validation is, at times, incomplete, inaccurate and/or untimely.
c. Communications among or between fleet units, bureaus and inventory control points are weak.
d. Data elements are not available or not developed. Many voids exist in availability or development of data to comply with criteria requirements; e.g., weight, cube, maintenance codes, military worth and usage data.
e. Type of operations supported varies among inventory control points. Wartime support is not provided by all allowances.

It has been claimed that one of the logical objectives of the program is to establish a uniform procedure for

the collection of shipboard usage data on both insurance and repetitive use items. Experience in truth, has no substitute; therefore data reflecting actual shipboard use of material is one of the prime factors in assisting allowance preparing activities in updating allowance lists.

Progress on this phase of the shipboard allowance list program has been expensive, slow and ineffective.

Another significant objective of the program is a requirement for a determination of the relative importance of equipments and repair parts as they relate to the successful accomplishment of assigned missions by ships operating independent of outside logistics support. CNO directed that this determination of military worth would be developed and that allowance lists would provide automatic information on the relative military importance of allowed items. Military worth is described as a value reflecting the effects of parts shortages on a ship's tactical capability. In arriving at this value for any part, two factors are to be considered, (1) equipment essentiality which measures the effect of equipment failures on the ship's ability to execute its assigned mission, and (2) part essentiality which measures the effect of part failure on the operability of the parent equipment.

Last for discussion, but obviously not the least important, is the dual objective of endeavoring to assure that operating ships are endurance loaded and that all

shipboard essential equipments have equal support. CNO requires that each ship have a maximum built-in endurance of allowance list items to enable the ship to perform its mission independent of outside logistic support. This self-support is not to be in balance but rather shall reflect uniform duration of support for all equipments.

CNO promulgated, for guidance, a definition of endurance loading, i.e., that process of selecting items having low cost, weight, cube and nondeteriorative characteristics and establishing stockage objectives for these items at levels to cover expected usage during the normal period between overhauls. The concept of endurance loading/balanced support requires that each allowance item be appropriately identified as to one of four types, i.e., a consumable, an insurance item, a repetitive use item subject to endurance load or repetitive use item not subject to endurance load. Further, balanced support connotes that all the allowance list preparing activities develop range and depth of allowances to provide uniform duration of support. Several data elements applicable to allowances are necessary to implement desired action under this objective, i.e., usage rates, weight, cube, military worth and deteriorative qualities. Further, data on shipboard stowage capacity for each material cognizance must be available to the allowance preparing activities.

To effectively implement this segment of the allowance list program known deficiencies must be removed. These are:

1. Varying interpretations of the letter and intent of the CNO objective.
2. The unilateral preparation of allowance lists. No single activity has cognizance over the total allowance list package for a ship. Balanced support, therefore, is difficult if not impossible to attain.
3. Item data is not available precluding the identification of allowance items as to their endurance load characteristics.
4. Equipment and parts have not been assigned military worth codes. Until this action is accomplished conceivably ships may be endurance loaded with non-essential material.

Summary

Many problems still exist; progress is painful; progress is slow; progress is necessary. The COSAL program has many facets and it is only one small segment of the entire logistics problem. It required four years to implement and at the end of that time, it was already outdated in many respects. The objectives are sound. The approach was dictated by the very magnitude of the effort. Its success must

be judged in the light of the positive accomplishments and the changing conditions with which it was confronted. During this period the Navy consisted of some eight hundred ships -- ships that were mobile, ships that had missions to perform. Logistics provides support; the tail does not wag the dog.

When one is firing at a moving target, he must "lead" it. Requirements must be determined in advance; past usage data are helpful but are limited to those areas where experience exists. Throughout the previous chapters reference has been made to military worth and military essentiality. The next several chapters will concentrate on this concept for determining repair part allowances.

CHAPTER III

DEVELOPMENT OF AN APPROACH TO THE UTILIZATION OF MILITARY ESSENTIALITY

Objective of the Coordinated Shipboard Allowance List (COSAL) Program

Because the effectiveness of the shipboard allowance list so strongly influences the combat readiness of naval ships, it has been a subject of great importance to the Navy in recent years. The application of scientific techniques to inventory policy has gained wide attention, and particular emphasis has been laid on research aimed at developing better stock level policies, thereby increasing the supply endurance of combatant ships. There has been considerable interest in maximizing the capability of combatant ships for operating independent of external supply and repair support.[1]

It was toward the accomplishment of this objective that the Coordinated Shipboard Allowance List (COSAL) Program was established in December 1956; its basic objective was to enhance the endurance of the operating forces. Towards this end, a basis for determining the relative

---

[1]Denicoff, Marvin and Henry Solomon, Toward the Formulation and Solution of the Allowance List Problem, George Washington University Research Project, Serial T-84/58 (21 May 1958), p. 1.

military importance of equipments and repair parts as they relate to the successful accomplishment of assigned missions by ships and aircraft independent of outside logistic support had to be established.

The first application of this program was to be in the development of coordinated shipboard allowance lists. The application to aviation equipment and repair parts allowance lists, not a part of the COSAL program, was to be subsequently explored. Further application was to be made to broader inventory management areas, including such functions as procurement, provisioning, the determination of system stock levels, disposal decisions, preparation of critical item lists, etc.[2]

Introduction of Military Worth Considerations

In order to advance the objective of the COSAL program, the George Washington University Logistics Research Project and the Advanced Supply System, Research and Development Division of the Bureau of Supplies and Accounts initiated an allowance list study on submarines in June, 1957.

An analysis of usage data from twelve sample submarines pointed out the necessity for developing an approach to the utilization of military worth, or essentiality, evaluations in the problem area. This study revealed that

---

[2]U.S. Navy Department, OPNAV Instruction 4423.1 of 17 March 1960, (Military Worth (Essentiality) Program).

approximately seventy-five percent of the installed technical items showed zero movement by each individual submarine over a four-year period. Of the items which did move, more than seventy percent were demanded only one time over these four years. The problem was further complicated by the lack of repetitive movement; for any one ship, less than one percent of the technical items used in the four-year period were used in every one of the four years. The problem thus resolved itself into the development of a method for treating those items which have shown zero usage in the past, but which may move in the future. More particularly, there was concern with pinpointing that segment of the ship's repair part population which is vital to the ship's existence independent of the past history or usage. Shipboard storage constraints, particularly critical in the case of submarines, and budgeting considerations are factors which influence this concern in the face of the usage pattern.[3]

While it has been recognized for some time that some concept and measurement of military worth is necessary for inventory systems, this need became pressing in the light of observed characteristics of demands for repair parts. The results obtained from the above analysis pointed out the immediate necessity for developing a feasible and operational

---

[3]Solomon, Henry, Joseph P. Fennell and Marvin Denicoff, A Method for Determining the Military Worth of Spare Parts, George Washington University Logistics Research Project, Serial T-82/58 (April 1958), pp. 1-2.

approach to military worth.[4]

Approach to the Allowance List Problem:
The U.S.S. TIRU Study

On the basis of the analysis of usage data of the twelve sample submarines, a decision was made to obtain worth estimates for the total component and part population range of a single combatant ship. The submarine, U.S.S. TIRU (SS 416), was chosen for this purpose. While the study was primarily directed at developing a measure of military worth (essentiality) which can be used as one of the several parameters in the determination of shipboard stock levels, the most important objective was to determine the feasibility of obtaining a relative measure of the seriousness of repair parts systems. Questionnaires developed for this purpose represent a first attempt at achieving what is basically a relative ranking of the importance of repair parts based on the essentiality of parts to components, and of components to the mission of the ship. Evaluations were obtained for approximately 1,300 components and approximately 31,600 repair part applications for these same components. Three independent evaluations were obtained for each component and two independent evaluations were obtained for the parts.

---

[4]Denicoff, Marvin, Joseph P. Fennell, and Henry Solomon, "Summary of a Method for Determining the Military Worth of Spare Parts," Naval Research Logistics Quarterly, NAVEXOS P-1278, Vol. 7, No. 3, (Sept. 1960), p. 221.

A principal goal of the above study, as stated earlier, was to develop allowance list techniques which maximize the independent afloat endurance of combatant ships. Independent afloat endurance refers to the capability of ships to accomplish tactical missions independent of reliance on external supply support. The importance of the maximization of independent operation derives from the thesis that our retaliatory power in the event of enemy attack is significantly dependent upon the degree of self-sufficiency attained by the operating fleet.[5]

Military Worth (Essentiality) Evaluations Defined

In this context, military worth, or essentiality, is defined as a relative ranking system which measures the effects of material shortages on a ship's capabilities. Two factors which influence the seriousness of a particular shortage are "mission effect," which measures the effects of the inoperability of specific items of equipment on the ship's capability for accomplishing its assigned mission; and "maintenance potential," which measures the effect of part failures on the operability of a parent component. Where such failures render the parent component inoperable, the "maintenance potential" factor considers the capability of the ship's force, in the event of a repair parts shortage,

---

[5]Solomon, et al., <u>A Method for Determining the Military Worth of Spare Parts</u>, ii.

to maintain the parent component in a satisfactory operable condition through on-board manufacture of the required part, through cannibalization, or by the employment of jury-rigging procedures.

Combining the factors "mission effect" and "maintenance potential" permits a relative evaluation of the seriousness of repair part shortages. For example, a repair-part-military-worth scale is conceived which includes the extremes, "high" military worth, and "low" military worth. At the one extreme - high military worth - the "mission effect" factor states that the inoperability of the equipment would necessitate termination of the mission; the "maintenance potential" factor states that part failure renders the parent component inoperable, the required part is not available, and cannibalization and jury-rigging procedures are infeasible. At the other extreme - low military worth - the "mission effect" factor states that inoperability of the equipment would have a negligible effect on the accomplishment of the mission; the "maintenance potential" factor states that the parent component will continue to operate satisfactorily without the necessity of replacing the failed part, or, should replacement be desired, on-board manufacture, cannibalization, or jury-rigging procedures are feasible.

Determinination of spare part essentiality, then, is a combination of both factors - "mission effect" and "maintenance potential." This is most evident when thought of

in terms of repair parts with similar design characteristics or a single repair part with multiple equipment applications. The military worth of similar repair parts will vary considerably if one is installed in a parent component with a low mission effect. Likewise, the military worth of similar repair parts installed in different parent components having the same mission effect will vary if the maintenance potential factor is high for one application and low for the other.

Therefore, in making repair part military worth estimates, two separate decisions are involved: a determination of "mission effect," which is a command decision, and a determination of "maintenance potential," which should be a decision by personnel with appropriate technical skills.[6]

Procedure Used to Obtain Military Worth Evaluations

For the allowance list study, a typical war-time situation for a fleet-type submarine of the U.S.S. TIRU class was prescribed. The assumptions were:

(1) The submarine was to go on a patrol in a specified area for a period of sixty days. The mission of this patrol was to seek out and sink any enemy shipping. In addition, the submarine was to report any incidental intelligence.

---

[6]*Ibid.*, pp. 3-4.

(2) While on patrol duty, because of the area of operations, it was expected that the submarine would be submerged an average of eighteen hours each day. The submarine would be snorkeling the necessary amount of time.

(3) It was to be expected that, during the sixty-day period of operations, no supply replenishment could be made for installed items. In addition, no repair support would be available from tenders, repair ships, or shore activities.

The questionnaires used in the study were designed to obtain separate evaluations for the two factors, "mission effect" and "maintenance potential" for the total component and repair part population range. Agreement was reached to obtain three independent evaluations for each parent component and two independent evaluations for each repair part. Component and repair part listings for recording the military-worth evaluations were prepared from population data decks supplied by the cognizant Supply Demand Control Points.

The "mission effect" (component) questionnaire described four situations which may result from the failure of a particular component. These range from component failure necessitating termination of the patrol action, to failures which introduce high- or moderate-risk factors in the accomplishment of the mission, to failures which have a negligible effect. These situations, or effects, were

coded numerically: 1, 2, 3, or 4, respectively. The participant determined which situation applied for each component in the study. Decisions were recorded in applicable code numbers on the component listings.

A code 1 decision (termination of patrol action) indicated a component failure, the seriousness of which would cause the ship to break-off the patrol and immediately return to port for repairs. A code 2 decision (high risk) indicated a failure which would introduce a calculated risk into the accomplishment of the mission, the risk being restrictive in terms of operational capability of the ship. Depending on the type of component which had failed, limitations such as choice of areas of operation, selection of targets, reduced defense capability, etc. might apply. The ship, however, would stay on station. A code 3 decision (moderate risk) indicated a failure which imposed a much less serious restriction on the accomplishment of the mission and wherein the component failure could often be compensated for; for example, by substitution of manual for mechanical operation. A code 4 decision (negligible risk) indicated a failure which imposed no restrictions on the accomplishment of the mission.

In cases where there were multiple quantities of particular components installed on the ship, the military worth evaluation would vary with the quantity installed. For example, where four components were installed, if all

four failed, the military worth evaluation code would be 1; if three failed, the military worth evaluation code would be 2; etc.

The "maintenance potential" questionnaire listed a series of five questions to be answered "true" or "false." An affirmative answer to any one of the questions had the effect of mitigating the seriousness of the shortage.

Question 1 had to do with the capability of the ship's force for making the installation of the required part. The remaining questions, predicated on an assumption of a part failure with no repair part in stock, had to do with the possibility of employing alternative resources for keeping the parent component operative for the stipulated sixty-day patrol period. Question 2 listed on-board manufacture of the required part as an alternative solution to the shortage problem. Repair capability of a damaged part is implied in the question, but is not explicitly listed. The large variety of damage possibilities precluded the use of the question in an explicit manner.

The third question dealt with the possibility of jury-rigging; the fourth question described a situation wherein the component would continue to operate satisfactorily despite the failure of the repair part under consideration, a situation representing the least serious type of failure; and the fifth, and final, question treated

the possibilities for cannibalization as an alternative solution to the shortage problem.[7]

The "mission effect" and "maintenance potential" questionnaires are illustrated on pages 79 and 80.

The components were divided into three general categories: (1) mechanical and electrical, (2) electronics, and (3) ordnance. For each of these categories, three independent answers were provided for each component. In order to arrive at a single military worth category for each component, then, it was necessary that the three independent answers be consolidated. In view of the observed nature of consistency among the three answers, it was decided that the use of the arithmetic mean would be an acceptable way of accomplishing this measure.

In the valuation of parts, the five questions were answered for each part application. All items were evaluated in regard to component applications, independent of the particular cognizant Inventory Manager. For example, the participants at the Ordnance Supply Office evaluated electronics and general stores parts installed on ordnance components as well as ordnance items installed on ordnance components.[8]

---

[7]_Ibid_., pp. 6-19.

[8]Denicoff, et al., _Naval Research Logistics Quarterly_, NAVEXOS P-1278, Vol. 7, No. 3, pp. 228-30.

Results of the U.S.S. TIRU Allowance List Study

The research group concluded that there were two important results of the allowance list study. First was the predominance of agreement among the independent answers for the component and repair part questionnaires. In the case of the components, substantial agreement among the participants was obtained for 1,132, or 92.4 per cent of the total number of components evaluated. Second was the count of the numbers of components and repair parts falling into each military worth category. Approximately three per cent of the total number of components evaluated were assigned to category 1; twelve per cent were assigned to category 2; forty-three per cent to category 3; and forty-two per cent to category 4. These findings were considered very significant because of their marked contrast to the widely held assumption of equal worth for all components at all times insofar as allowance list decisions were concerned.

As for the military worth of repair parts, an average of sixty-six per cent of the parts fell into the lower worth categories. They noted that, even with such restricted facilities for repair work on board submarines, twelve per cent of the technical items could be manufactured and/or jury-rigged. Another very significant observation was that almost thirteen per cent of the items could fail without disturbing the operation of the parent

component. Certainly, with space as a major constraint, these items would have a low priority for on-board loading considerations. The results of the evaluations of repair parts clearly indicated that the range of technical items vitally necessary for a vessel to fulfill its mission requirements was quite limited. It appeared almost certain, therefore, that there was strong potential for reducing the on board range of repair parts, without jeopardizing the readiness of combatant ships. Certainly, the use of military worth data would afford more positive control over the range of items for ship's allowance lists, and there were even wider implications in the areas of procurement and distribution, provisioning, the determination of system stock levels, disposal decisions, the preparation of critical item lists, etc.[9]

---

[9]Ibid., pp. 227-34.

CHAPTER IV

PRESENT EFFORTS TOWARD OPTIMIZING REPAIR PARTS PROVISIONING

The Increasing Importance of Systematic Allowance List Formulation

The basic reason for supplying and maintaining a shipboard repair parts inventory or allowance list is to support strategic plans. These plans include the specific current strategic plan or plans and possibly uncertain future strategic plans. In order to insure maximum support of these plans through shipboard inventories or allowance lists the requirements and priorities of the imposed strategic plans must be known or assumed. This kind of input data has long been available in greater or lesser detail and accuracy. It follows that the need for some concept and quantitative measurement of military worth has long been recognized as a necessary parameter for designing effective inventory systems.

This need has become more pressing as the importance, complexity and expense of shipboard equipment has so radically increased in the last decade. The advent of the Fleet Ballistic Missile (Polaris) Submarines again focused attention upon the need for a rational, quantitative methodology to provide maximum allowance list effectiveness,

and thereby support a maximum combat effectiveness. The proposed operations of this class ship were well defined with a singleness of purpose. Further, these combat ships must operate independent of any external supply or repair support for cruises of the order of sixty days.[1]

The subject class of ships are submarines wherein space has historically been a most critical problem. In this class of vessel the space limitation would be reached before concern would have to be given to the aggregate weight of the items carried. In surface vessels or very deep diving submarines, weight limitation problems would also exist.

Optimum COSAL Research Efforts on a Polaris Submarine

The investigative work on the USS TIRU, previously described, provided a background for an Optimum Coordinated Ship Allowance List Program (Optimum COSAL) for the Polaris Submarines. The purpose of the Optimum COSAL study was to develop mathematical models or techniques for making optimum allowance list range and depth determinations. The methodology proposed by the George Washington University Logistics Research Project under the Office of Naval Research Contract Nonr 761(06) includes consideration of military worth and any constraint which might ultimately

---

[1]U.S. Navy Department, Special Projects Office, S.P. Instruction 5000.2 of 5 May 1960.

be imposed; e.g. space, weight, budget, repairability, etc.[2] What had primarily been a research effort up until 1960, became a Navy-wide program.[3]

Major Features of Optimum COSAL

A major feature of the Optimum COSAL Program is the provision for Navy policy control of allowance lists. The Navy can conduct feasibility tests of an extremely wide range of alternative policies before actually stocking a ship in terms of a particular policy. It will also allow the operating forces to make a final policy decision and insure that the allowance list will reflect that decision. Changes in equippage or tactical missions can also be quickly integrated into existing data to generate a new allowance list reflecting these kinds of changes. Further, inventory managers can have information available in a routine manner which will provide statistical information on the distribution of unit prices and cubes, items by essentiality ratings, and usage estimates. Allowance list summary data available would include (1) the dollar value of the list, (2) the storage volume requirements of the

---

[2]Office of Naval Research, Logistics and Mathematical Statistics Branch, Polaris the Optimum COSAL Program, A Report Prepared by the Office of Naval Research in Conjunction with the Bureau of Supplies and Accounts, the Special Projects Office and the George Washington University, June 1961.

[3]U.S. Navy Department, OPNAV Instruction 4423.1 of 17 March 1960.

list, (3) the range and depth of repair parts, (4) the component coverage and (5) the part population coverage. Possibly the most important feature will be the quality control which inventory managers could exercise over the input data from which the allowance list is generated.

The implementation of the Optimum COSAL technique can result in significant improvements not only for logistics planning but for actual operations as well. The speed and flexibility of list generation once the requisite input data has been accumulated is one of the advantages of this approach. Allowance lists tailored to operating policies can readily accommodate changes of policy and input data. Alternative policy listings can be examined and quantitative evaluation of any chosen policy list is possible.

Input Data Requirements

In order that the possible advantages of this operations research approach can be realized, the following requirements must be met:

(1) Quantitative data of sufficient accuracy must be accumulated for all of the parameters that affect the goals of proper allowance list stocking.

(2) Quantitative and consistent goals or objectives of shipboard repair parts allowance lists must be formulated.

(3) Mathematical models which yield a sufficiently accurate output in terms of the stated goals when fed imputs of all the causative parameters must be designed. These models must then be tested to insure their validity.

(4) Continuing evaluation of allowance lists so generated will be necessary to insure the validity of the input data, the model used and the goals or objectives stipulated.

In April 1960, a program was initiated by the Special Projects Office for allowance list research to be directed to the USS GEORGE WASHINGTON (SSB(N)598), the first of the Fleet Ballistic Missile Submarines.[4] The project was coordinated by, and under the management control of the Bureau of Supplies and Accounts.[5] The research staff was composed of the same individuals who had conducted the previous three-year studies. Technical data were gathered from the following sources: Ship's Parts Control Center, Ordnance Supply Office, Electronics Supply Office, Bureau of Ships, Bureau of Supplies and Accounts, Polaris contractors, Submarine Squadron 14, USS GEORGE WASHINGTON, and USS PATRICK HENRY.[6]

---

[4] U.S. Navy Department, Special Projects Office Instruction 5000.1 of 26 March 1960.

[5] U.S. Navy Department, loc. cit.

[6] U.S. Navy Department, Special Projects Office Instruction 5000.3 of 28 July 1960.

The first phases of the program included the required completion of the following support programs:

1. Acquisition of complete and accurate installed component and equipment population data,

2. Acquisition of military essentiality data,

3. Development of mathematical models or techniques, and

4. Programming the resultant model to yield various allowance lists.

Population Data -- Acquisition of complete and accurate listings of the installed components and equipment, the first requirement, proved more difficult than would at first be imagined. In fact, to date, some year and one-half later, complete and current listings of the approximately 3,500 installed components and equipment are not yet available. Parts data including unit price, unit cube, weight, usage estimates where practicable, etc. were required for approximately 62,000 items. The accuracies of these listings were of course dependent upon the installed component and equipment lists.

Essentiality Data -- The requirement for military essentiality data necessitated the use of the previously developed technique for making essentiality determinations. A training course in essentiality rating techniques was next required to insure consistency of essentiality data. The

actual collection and tabulation of data was then followed by the development of a technique for classifying the raw essentiality information into discreet and meaningful categories.

Objective measurement and comparison of the military essentiality on all installed equipments, components and applicable repair parts were deemed necessary to provide inputs to spare parts allowance list formulation. The relative ranking of the raw military essentiality data developed a systematic grouping which measured the effects of part failure on the capability of the total shipboard Polaris Weapon System. This fundamental piece of information does not in itself provide a solution to the allowance list problem. Along with other kinds of data both on the size, price, etc. of each part; the particular operating policies, and assigned missions; an optimum solution may be obtained.

The military worth of a particular part is based upon a consideration of the part-to-component-to-equipment-to-mission relationship. The first concern is the effect of a failure of a particular part on the operability of its parent component. Second, if the part failure results in a component failure, the effect of the component failure on the parent equipment is of concern. Finally, attention is focused upon the consequences in terms of the ship's mission of the possible failure of the parent equipment.

To acquire this kind of data a series of three separate questionnaires;one for equipment, one for components, and one for repair parts was developed and utilized. Three independent military essentiality answers for each installed equipment and component were obtained. The participants in this portion of the program were: the equipment contractors, the concerned technical bureau personnel, and operating fleet personnel. Three independent evaluations were considered necessary to provide a measure of consistency and to point up any bias introduced by a particular participant. In the case of the contractors, the questionnaires were answered by design or systems engineers with experience in the particular sub-system being considered. Civilian engineers were utilized in the technical bureaus. In every case purposeful effort was made to utilize personnel with experience and training in the Polaris Weapons System. Questionnaires included a statement of the assumed typical patrol requirements of the ship. The questionnaires,when completed, provided data as to: (1) the effect of an equipment or component failure on the stipulated mission effectiveness of the ship, (2) redundancy or the availability of duplication of installed equipments and components, and (3) the availability of alternatives or emergency methods which could effect temporary repair and make continued operations possible. Further, part questionnaires provided

data as to the effect of each part failure on its parent component and whether the part was considered installable by the ship's force.

All the above data were coded numerically. In order to employ the essentiality obtained from the three independent evaluations a single military essentiality code was required for each part application. The input data were at least 90% consistent (two or more agreements in all category questions). Where there were no agreements a majority rule was applied to consolidate the independent source data. The consolidated part data along with the data on its parent component and equipment was then listed or ranked in priorities of military essentiality. The highest ranking would refer to a particular part which could be installed by the ship's force and is essential to the operation of its parent component. The parent component for this part vitally affects the operation of its parent equipment. There is no redundancy or emergency method available to reestablish the equipment's operability. Finally, the failure of the parent equipment would so degrade the capability of the ship as to abort the mission, there again being no redundant or alternative emergency method available to perform the necessary function.

Part essentialities were grouped down to the lowest rank where part, component and equipment failures have negligible mission effect, and where redundant or alternative

model simultaneously considers all item characteristics of all items in light of the expected value of the item for the ship's military mission. Both present models employ a negative binomial distribution of future demand probability for each repair part. This statistical distribution is utilized because of the weight of emperical evidence gained by analyses of historical demand patterns for moderate and high usage shipboard repair parts. Distribution of extremely low usage parts is presumed to follow this same distribution.

Model Programming -- The final aspect of the simulation program included the preparation of various allowance lists, each list reflective of a particular operational policy.[8] Approximately forty different lists, each based upon computations for the total installed population of technical repair parts, were prepared. These were reduced to eighteen lists, and then to six which were considered as representative of the Optimum COSAL requirements.[9] These lists were reflective of particular mixes

---

[8] Interview with Herbert G. Mills, Commander, Supply Corps, U.S. Navy, Director, Advanced Logistics Research Division, Bureau of Supplies and Accounts, December 14,1961.

[9] Polaris, the Optimum COSAL Program, a Report Prepared by the Office of Naval Research, Bureau of Supplies and Accounts, Special Projects Office and The George Washington University under the Logistics Research Project, Contract Nonr761(06), Project NR 347 008 of June 1961.

of operational policies, e.g., minimize essentiality weighted shortages, minimize dollar and/or space requirements, maximize protection levels, etc. The six lists were forwarded for military evaluation.

The USS GEORGE WASHINGTON has been operating for about one year. The repair parts demand data generated in this period indicate that the allowances generated by the research project are more responsive and well-balanced than the actual on-board allowance. The testing period has not yet generated sufficient data to determine any quantitative relationships between the actual and the various proposed allowance lists. Preliminary qualitative comparisons do now indicate that the Cardinal Model listing would have provided fewer high military worth part shortages; would have required 17% less storage volume; would have cost 10% ($2,190,000 vs. $2,430,000) less; would have provided equal range of repair parts; and would have increased depth three-fold.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary of Developments

The mission of the Navy is implicit in law and directives of the Secretary of Defense - a continuing responsibility to be "organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea, ..." The mission is not changed by technological advances; the necessity for employment of Naval forces remains constant. The successive employment of the carpenter and the sail-maker, the repair part box, and the COSAL and the development of the presently proposed optimum allowance list have been necessary to support this mission. In the historical presentation of the Navy's progress in the management of repair parts' inventories, the deficiencies of each former program have been enumerated. What has not been emphasized is that the evolution of each program has closely paralleled the ever-increasing trend toward centralization of military management.

The equipment spare parts box fulfilled the needs of the individual responsible for the maintenance of that particular equipment. Multiple and decentralized stocking policies created excessive duplication of parts. The lack

of a common identification system limited inter-equipment use of common parts. The Integrated Supply System provided common identification for identicial parts and eliminated much of the duplication of inventories in the ashore supply depots. Shipboard inventory duplications were still prevalent. The continuation of equipment repair part box stowage in support of the decentralized shipboard organization limited improvement in this area. The COSAL program and the bin-drawer stowage program were designed to eliminate inter-system and therefore inter-shipboard-department duplication. Much has been accomplished; much remains to be accomplished. Many of the COSAL deficiencies that exist today are simply the result of administrative lag. Most of this administrative lag, however, is the result of the continuing decentralized control.

The exponentially accelerating pace of scientific and technological developments in military equipment has had a major impact on logistic requirement determinations. Present research includes a study of single-item requirements and has resulted in the development of a methodology for preparation of shipboard repair part allowance lists designed to increase the military effectiveness of combatant ships. A series of pilot allowance lists for a nuclear-powered submarine carrying ballistic missiles have been designed to permit maximum endurance at sea under

specific mission requirements. This approach has been accepted as the most promising route to the overall objectives of the Navy's repair parts program.

Conclusions and Recommendations

The COSAL Program

The Integrated Supply System was, at best, a compromise. The "marriage of the technical and supply functions at the inventory control point" was actually an approach that permitted the continued existence of separate repair parts systems. The division between "technical matters" and "supply functions" was a concession to command prerogative. To further complicate the issue, the system was, for all practical purposes, cut off from the fleet -- the ultimate user of its outputs. Recommendations and complaints had a long, time-consuming path to follow. Functions and authority were not clearly defined. Coordination between the widely separated, interested parties was difficult due to the inherent weaknesses in any communications system.

The COSAL program eliminates very few of these weaknesses. At the shipboard level coordination is improved and duplication reduced, but the control centers (The Supply Demand Control Points, the Technical Bureaus, the Bureau of Supplies and Accounts and the Fleet Commanders) all retain their individual prerogatives. Final responsibility rests with the Chief of Naval

Operations, as it does in all military matters, but enforceable coordination is non-existent because of the division of authority.

The COSAL program is not passe. It is based upon sound principles. It is, and will be at least for the near future, the system in being. The weaknesses can and should be strengthened. The advent of single-managers for common defense materials and the recently approved Defense Supply Agency for control and coordination of single-managers make it all the more imperative that the Navy establish centralized control of the repair parts systems. It is recommended that:

1. The Navy establish a single inventory control point for the management of all repair part inventories.

2. This inventory control point be staffed with technical supply and line (operating) personnel.

3. The Bureau of Supplies and Accounts, Technical Bureaus, Fleet Commanders, and the Chief of Naval Operations delegate the authority for allowance list requirements determinations, preparation and management to the Commanding Officer of this activity.

4. Direct lines of communications be established with the Bureau of Supplies and Accounts, the Technical Bureaus, the Fleet Commanders and the Chief of Naval Operations to promote a free exchange of data relating to requirements and performance.

5. The Commanding Officer of this activity be responsible to the Chief of the Bureau of Supplies and Accounts for management, to the Chiefs of the Technical Bureaus for technical guidance, to the Fleet Commanders for

> compliance with specific shipboard requirements and to the Chief of Naval Operations for overall policy guidance.

Recommendation (5) above, is made with the full recognition of the problems it will generate. The division of responsibility will be continued. The present line and staff organizational structure of the Navy Department requires such a division. The alternative is to place the proposed activity under the direct operational and management control of the Chief of Naval Operations. It is considered that this would defeat its purpose. Coordination, cooperation and control are not necessarily more enforceable because of the higher organizational level to which a commnd reports. Direction is needed and exists by virtue of the responsibility and authority vested in the Chief of Naval Operations. Coordination of the functions of all interested parties -- supply, technical and operations -- must be accomplished at a level commensurate with the problem. It is considered that this can be accomplished at the organizational level proposed. Each interested party will look to only one activity for the accomplishment of its repair part support requirements. This activity will be in a position not only to evaluate the effect of these requirements on an overall system basis but will have to consider the vested interests of all parties in order to achieve universal acceptance of its

actions. Acceptance is absolutely necessary if the system is to be effective. Acceptance cannot be directed. Control must be a voluntary action at each level of the organizational structure if it is to be achieved.

The Military Essentiality Approach

The approach to today's multifaceted shipboard carried repair parts problem can be paralleled to Mr. Hitch's proposed Department of Defense programming techniques. In each case the overall problem is to maximize probable effectiveness with minimal drain on resources. Mr. Hitch's proposed program is based on, "the establishment of machinery . . . within the Office of the Secretary of Defense to consolidate, review, and analyze in a systematic manner the programs developed by the Military Departments." The requirement for such machinery is based upon "the great technical complexity of modern-day weapons, their lengthy period of development, their tremendous combat power, and their enormous costs place an extraordinary premium on the sound choice of major weapons systems in relation to tasks and missions." Major problems in this proposed approach were recognized early in its conception.

> . . . much more work has to be done on the analysis of military effectiveness. In this connection, I would like to point out that a description of a weapon system, no matter how many adjectives it uses, is not a substitute for an evaluation of its military effectiveness, in terms of the mission it is designed to perform. Admittedly, this is a very difficult area of analysis.

> . . . we will have to develop a mechanism which will permit us to make prompt program adjustments in response to changes in the international situation, in technology and in requirements — at any time during the planning-programming-budgeting cycle.[1]

Mr. Hitch has thereby indicated two major requirements for any planning program: ability to evaluate effectiveness and ability to sense and adjust to changes as the program proceeds. To make sound decisions concerning such a program, essential facts and analyses are required. The necessary data includes: (1) alternatives available, (2) probabilities of fixed levels of effectiveness for each alternative and (3) the total cost of each alternative. This is commonly referred to as the operations research approach.

This operations research approach to determine the underlying principles and the quantitative analysis of the probable results of any of the infinite alternative repair part allowance lists appears most promising. Centralized control of allowance list formulation and decisions is, however, alien to the time-honored precept of the operational commander's control over his logistics support. Before the commander will waive this prerogative he must recognize the advantages of centralized control. He must

---

[1]Remarks of the Assistant Secretary of Defense, Charles J. Hitch before the American Society of Military Comptrollers, The Pentagon, Washington, D. C., Sept. 21, 1961.

understand and be convinced of the validity of the methodologies being introduced. He must be cognizant of the probabilistic approach, the optimization theory and the possible individual shortages that may arise.

Scientists, mathematicians and engineers are, today, required to combine their talents and academic diciplines to develop the tools and strategies of future wars. It would logically follow that the same kind of diverse scientific investigation of the Navy logistics problem is also now necessary. Sound rational, consolidated decisions within the repair parts allowance problem area must include logical analyses considering the following factors:

1. The unlimited alternative repair parts load lists possible.
2. The relative probable effectivesness of each alternative.
3. The full cost of each alternative.

The probable effectiveness of each alternative list must be quantitatively determinable in terms of the stipulated military missions. The Optimum Coordinated Ship's Allowance List (Optimum COSAL) program is based upon such a rational, quantitative operations research approach.

The most basic and obvious initial data required before this systematic comparison can be commenced is a complete and accurate part, component and equipment

population listing. The central accumulation of such data is not the straightforward process it would appear to be. Decentralization of technical control of systems and equipments to the various bureaus and delegation of some of this authority to subordinate commands, equipment contractors, ship builders, overhaul and repair activities and to the ship's commanders makes retrieval of complete population data very difficult. Further, the dynamic nature of component and equipment replacement or modification creates an ever-changing population listing.

To meet this problem a central data repository for part, component and equipment population information must be established. It would seem consistent to locate this repository within the data processing center which will formulate the Optimum COSAL's.

Military worth and probable demand data must be available in order to evaluate the relative effectiveness of the possible repair parts load lists created from the total population data.

The present research on Optimum COSAL for the USS GEORGE WASHINGTON cannot be fitted directly to other submarine classes, surface ships or aircraft designed for multiple possible mission assignments. In order that simultaneous consideration of all possible repair part essentiality codes is possible, the following procedure is recommended: Collect raw essentiality data from two

or more independent sources relating the essentiality of:

1. The particular part to its parent component,
2. The particular component to its parent equipment,
3. The particular equipment to each system it may support,
4. Each particular system to the ship or unit,
5. The particular ship or unit to each mission it might be called upon to support, and finally,
6. The importance or essentiality of each particular mission.

An aggregate, weighted, single essentiality code for each part could then be determined by first, separate essentiality coding of each of the six ratings above. These codes could be designated: (2) for critical essentiality, (1) for restrictiveness or risk if demand could not be fulfilled, and (0) for minimal consequence. An aggregate code could then be determined by noting the sequence of the codes in each of the six ratings. Installability of parts, redundancy and alternatives for repair can be coded and added to the above for computer programming.

Admittedly this additional data will complicate the problem by adding additional rankings of military essentiality codes. Programming the computer with a variation of the present mathematical models will be necessary. Though the program will be increasingly complex, nothing really new in approach is suggested. For a

balanced, Navy-wide program, these additional essentiality ratings are considered necessary.

In order that the probable demand rate can be considered with each part's essentiality code, usage data is needed. For very slow moving repair parts the validity of estimated usage data must be questioned. In estimating future usage the equipment designer or system engineer is, in fact, estimating the mean time to failure for each part performing each particular function. The reciprocal of the estimated mean time to failure will be an estimated demand rate due to independent part failure.

Actual usage data for a particular part performing a particular function will be the aggregate result of independent part failure (estimated above) and other causes. For example, cascading failures -- failures caused by malfunctioning or failure of other associated parts, components or equipment -- may generate actual usage. Further, the unnecessary usage caused by replacement of parts in the attempt to localize and rectify a complex equipment malfunction will produce usage. Shelf life or storage deterioration and faulty repair parts will tend also to increase usage. Variations of operating environment (temperature, humidity, vibration, power fluctuations, etc.) will also have a bearing upon estimated part life.

The present demand estimates, to represent probable fleet usage, should explicitly include the above factors.

The estimates must also include statistical deviation from the mean in order that assurance or risk can be quantitatively evaluated.

Central accumulation of valid usage data from fleet units and more realistic demand estimates will be necessary input parameters to the evaluation of allowance list effectiveness. Correlation of demand estimates and actual usage data, and updating of future demand rates and rate deviations will be a continuing requirement.

Another basic problem area is the assignment of full or total costs to each of the possible allowance list alternatives. Mr. Hitch has also recognized that " . . . good total cost information is not yet available for many of the proposed program elements." He is here referring to total cost over the full service life of the program element. Cost data for alternative allowance lists must also consider the total or full cost. The idea of full cost can be defined to include:

1. The dollar price of procuring and delivering the load list material.
2. The cost, throughout the ship or aircraft's life, of providing for
   a) Space or volume allocated to repair parts stowage,
   b) Weight and/or moment reserved for stowage,

c) Stowage facilities to provide for accessibility,

d) Manpower and tools necessary to permit utilization of the load list repair parts,

e) Training expense to provide part replacement and adjustment skills, and

f) The necessary consumables, berthing, messing, sanitary and other support facilities required by the maintenance personnel.

Assignment of accurate dollar values for all of these cost factors is not yet included in the Optimum COSAL program. To be able to quantitatively analyze the cost vs. effectiveness of any alternative allowance list over an extended period of time will require knowledge of all the elements that make up total cost.

General

The recommendations made herein are considered to be consistent and complementary. The single inventory control point would serve as the inventory manager, the central data repository, the data processing center, the research coordinator and the mediator of interests. The assignment of the research function to this activity will eliminate the duplication of data collection, reduce communications and provide for improved understanding of the problems that need to be considered.

Areas for Future Consideration

A study such as this would be incomplete without some consideration of the future. Recent research and development work on atomic reactors and unmanned, satellite-borne electronic systems should point up the possibilities and approaches to the reduction of maintenance. A systematic evaluation of the advantages of this kind of approach (reduction in cost of required repair parts, reduction in stowage volume and weight requirements, reduction in necessary training, tools and test equipment savings resulting from reduced maintenance personnel requirements, increased equipment reliability, etc.) can be weighed against the additional expense of design, test, manufacture and installation of the more reliable equipment. With the same approach, systems capable of self-maintenance can be evaluated. Here equipment designed with built-in redundant elements cross-connected by automatic switching units could provide repair parts as an integral built-in part of the equipment. Various compromise approaches could also be evaluated. For example, preassembled, plug-in components is one compromise which enhances equipment maintainability by decreasing the inoperable period resulting from a part failure and reduces the manpower, training and tools necessary to effect a repair. Additional costs must be weighed against these apparent advantages.

Evaluation of basic ship design alternatives such as system and equipment design, general arrangement and allocation of space, weight and moment reserves, maintenance and replacement policies, duplication, redundancy and secondary systems, future research requirements, etc., can also be accomplished through this scientific approach.

MISSION-EFFECT QUESTIONNAIRE

<u>Mission Statement</u>

1. Fleet-type submarine, TIRU class.
2. Sixty-day wartime patrol.
3. Submerged 18 hours a day. Normal snorkeling.
4. Complete isolation from supply or maintenance support.

<u>Assumptions</u>

1. In performance of the stated mission, the component under consideration fails.
2. Repair cannot be accomplished.

<u>Questions</u>

T ▱ F ▱ 1. Inoperability of the component would necessitate the termination of the patrol action.

T ▱ F ▱ 2. Inoperability of the component would introduce a high-risk factor in the accomplishment of the mission.

T ▱ F ▱ 3. Inoperability of the component would introduce a moderate-risk factor in the accomplishment of the mission.

T ▱ F ▱ 4. Inoperability of the component would have a negligible effect on the accomplishment of the mission.

MAINTENANCE POTENTIAL QUESTIONNAIRE

T	F	
/__/	/__/	1. Replacement can be accomplished by the ship's force.
/__/	/__/	2. The required replacement part can be manufactured by the ship's force with the machinery available on the ship.
/__/	/__/	3. The equipment can be made to function through known jury-rigging procedures. No substitute spare parts are required.
/__/	/__/	4. The equipment will continue to operate satisfactorily for the stipulated 60-day period without a part replacement being made and without the necessity for jury-rigging. If there is a reduced efficiency, such reduction is acceptable for the operation of the equipment.
/__/	/__/	5. The part <u>can</u> be removed intact (without damage to the part) from the equipment under consideration.

USS GEORGE WASHINGTON
(SSBN - 598)

25,000 ITEMS $1,549,000

SOURCE: SUPPLY AVAILABILITY REPORT
21 OCTOBER 1960

USS SEA FOX (SS- 402)

6,291 ITEMS

$93,171

SOURCE: SUPPLY AVAILABILITY REPORT
28 JULY 1960

USS FECHTELER (DDR - 870)

15,431 ITEMS **$236,700**

SOURCE: SUPPLY AVAILABILITY REPORT
2 NOVEMBER 1960

USS MIDWAY (CVA - 41)

28,800 ITEMS $917, 000

(EXCLUDES "R" COG)

SOURCE: SUPPLY AVAILABILITY REPORT
9 SEPT 1960

BIBLIOGRAPHY

Denicoff, Marvin, Joseph P. Fennell and Henry Solomon. Requirements Determination, Progress Report No. 1. The George Washington University Logistics Research Project, Technical Paper Serial 59/57 (June 1957).

Denicoff, Marvin, Joseph P. Fennell and Henry Solomon. "Summary of A Method for Determining the Military Worth of Spare Parts." Naval Research Logistics Quarterly, NAVEXOS P-1278, 7, No.3(September 1960), 221-34.

Denicoff, Marvin and Henry Solomon. Toward the Formulation and Solution of the Allowance List Problem. The George Washington University Logistics Research Project, Technical Paper Serial T-84/58 (May 1958).

Department of the Navy, Bureau of Supplies and Accounts. A New and Improved Approach to Allowance List Coordination, NAVSANDA Publication 373 (April 1959).

Department of the Navy, Office of the Chief of Naval Operations. "Military Worth (Essentiality)Program." OPNAV Instruction 4423.1 of 17 March 1960.

Hamilton, J.E. Evaluation of Data for the USS TIRU (SS 416). The George Washington University Logistics Research Project, Technical Paper Serial T-98/59 (February 1959).

Hamilton, J.E. Supplement to Evaluation of Data for the USS TIRU (SS 416). The George Washington University Logistics Research Project, Technical Paper Serial T-98(a)/59 (May 1959).

Karr, H.W. "A Method of Estimating Spare-Part Essentiality," Naval Research Logistics Quarterly, NAVEXOS P-1278, 5, No. 1 (January 1958) 29-42.

"Military Essentiality and Optimum COSALs: The Search for the Perfect Top-Off." Monthly Newsletter, Magazine of the Navy Supply Corps, XXIV, No. 9 (September 1961), 6-8.

Polaris: The Optimum COSAL Program. The George Washington University Logistics Research Project No. 347008 (June 1961).

Solomon, Henry, Joseph P. Fennell and Marvin Denicoff. A Method for Determining the Military Worth of Spare Parts. The George Washington University Logistics Research Project, Technical Paper Serial T-82/58 (April 1958).

Solomon, Henry and Marvin Denicoff. Simulations of Alternative Allowance List Policies. The George Washington University Logistics Research Project, Technical Paper Serial T-102/59 (May 1959).

Department of the Navy, Bureau of Supplies and Accounts. BUSANDA Instruction 4441.3A of 4 January, 1960.

Department of the Navy, Bureau of Supplies and Accounts. Supply Support of the Navy, NAVSANDA Publication 340, September 15, 1957.

Department of the Navy, Office of the Chief of Naval Operations. OPNAV Instruction 4441.4 of 20 December, 1956.

Hitch, Charles J. and McKean, R. N. The Economics of Defense in the Nuclear Age. Harvard University Press, 1960.

Williams, Benjamin H. Emergency Management of the National Economy, Vol. XIV, Distribution Logistics. Washington: Industrial College of the Armed Forces, 1955.

Department of the Navy, Special Projects Office, S. P. Instruction 5000.2 of 5 May 1960.

Department of the Navy, Special Projects Office, S.P. Instruction 5000.1 of 26 March 1960.

Department of the Navy, Special Projects Office, S.P. Instruction 5000.3 of 28 July 1960.

Department of the Navy, Bureau of Supplies and Accounts, "Coordinated Shipboard Allowance List (COSAL) Program; policy and procedures for," BUSANDA Instruction 4441.2A of 3 May 1960.

Department of the Navy, Office of the Chief of Naval Operations, OPNAV Instruction 4441.5A of 10 January 1961.

Department of the Navy, Bureau of Supplies and Accounts, BUSANDA Instruction 4441.5 of 14 April 1960.

Department of the Navy, Bureau of Supplies and Accounts, Military Worth (Essentiality) Program, Semiannual Report of Progress, 4 April 1961.

Department of the Navy, Bureau of Supplies and Accounts, A New Approach to Allowance Lists, March 1959.

Department of Navy, Bureau of Supplies and Accounts, Advanced Supply System Research and Development Division, Military Worth (Essentiality), 24 April 1958.

Solomon, Henry; Lewis, Raymond; and Denicoff, Marvin. Report on Electronics and Ordnance Usage Data for Nine Submarines, The George Washington University Logistics Research Project, Technical Paper Serial T-97/59 of 15 January 1959.

UNPUBLISHED MATERIAL

Department of the Navy, Bureau of Supplies and Accounts, Fleet Operations Division, Policy Advisory Council Presentation, February, 1961.

Hitch, Charles J., Assistant Secretary of Defense, Speech presented to the meeting of the American Society of Military Comptrollers, the Pentagon, Washington, D. C., September 21, 1961.

INTERVIEWS WITH

Baker, John A., Head, Allowance/Load List Section, Fleet Programs/Readiness Branch, Bureau of Supplies and Accounts, various times, August - December, 1961.

Busby, J. ., Commander, Supply Corps, U.S. Navy, Director, Advanced Logistics Research Division, Bureau of Supplies and Accounts, August, 1961.

Denicoff, Marvin, Project Manager, Advanced Logistics Research Division, Bureau of Supplies and Accounts, August, 1961.

Marx, J. H., Lieutenant Commander, Supply Corps, U.S. Navy, Special Assistant, Fleet Ballistic Missile Program Division, Bureau of Supplies and Accounts, August, 1961.

Mills, Herbert G., Commander, Supply Corps, U.S. Navy, Director, Advanced Logistic Research Division, Bureau of Supplies and Accounts, December 14, 1961.

Woodward, W. K., Commander, Supply Corps, U.S. Navy, Assistant Director, Fleet Operations Division, Bureau of Supplies and Accounts, various times, August - December, 1961.